Departamento de Física
UBA exactas

MATERIA OPTATIVA Y DE DOCTORADO

FÍSICA DEL ATTOSEGUNDO

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The Nobel Prize in Physics 2023

"for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter"

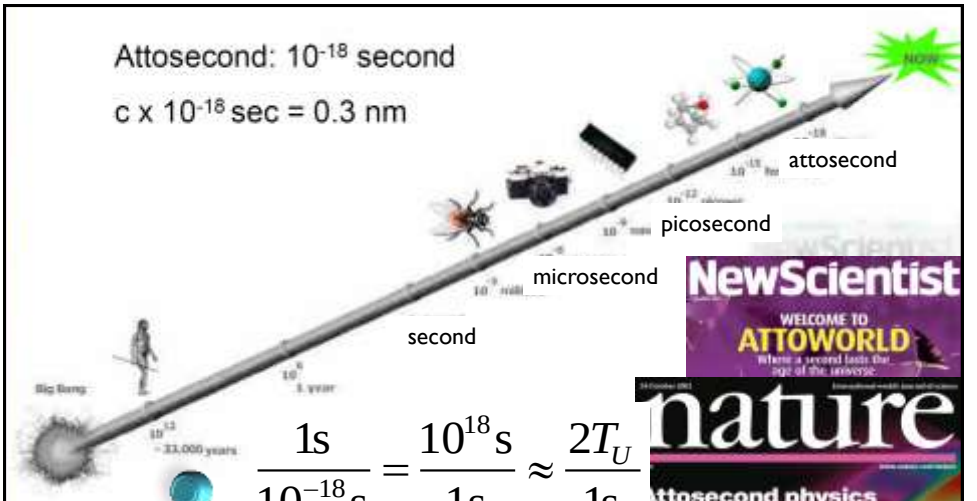
PIERRE AGOSTINI
PhD 1968 from Aix-Marseille University, France. Professor at The Ohio State University, Columbus, USA.

FERENC KRAUSZ
Born 1962 in Mór, Hungary. PhD 1991 from Vienna University of Technology, Austria. Director at Max Planck Institute of Quantum Optics, Garching and Professor at Ludwig-Maximilians-Universität München, Germany.

ANNE L'HUILLIER
Born 1958 in Paris, France. PhD 1986 from University Pierre and Marie Curie, Paris, France. Professor at Lund University, Sweden.

Attosecond: 10^{-18} second

c x 10^{-18} sec = 0.3 nm

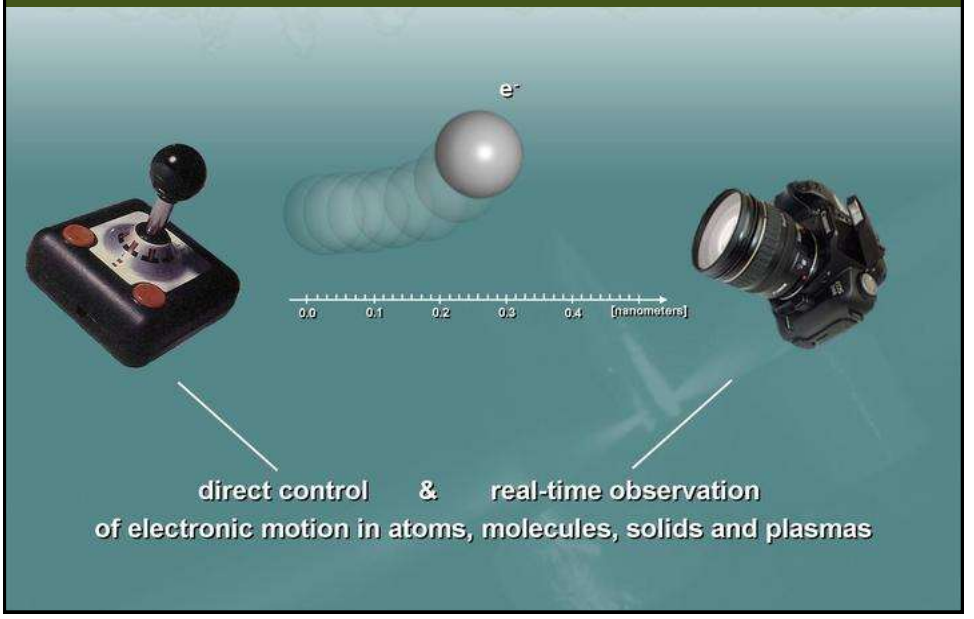


$$\frac{1\text{s}}{10^{-18}\text{s}} = \frac{10^{18}\text{s}}{1\text{s}} \approx \frac{2T_U}{1\text{s}}$$

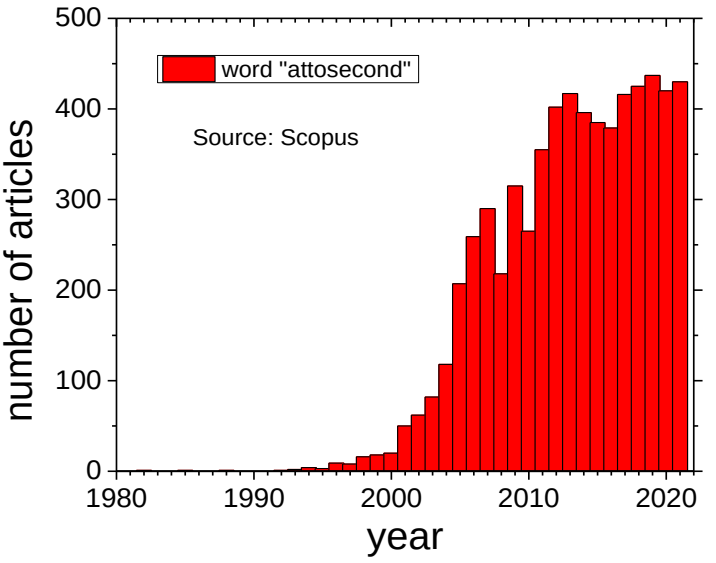
Hydrogen Atom

$$T_{orb} = \frac{2\pi a_0}{v} \approx 150\,\text{as}$$

Attosecond physics aims at gaining insight into the motion of electrons on atomic scales



ATTOSECOND PHYSICS



Material en la págima web de la materia:

PDF de todas las clases teóricas con antelación: La idea es imprimirlas antes de las clases para hacer anotaciones sobre ellas.

Lista de ejercicios a entregar

Material adicional

Régimen de aprobación:

(i) Parcial: Entrega de ejercicios y resolución de un problema en forma numérica.

(ii) Examen final: Exposición de un tema especial (paper o capítulo de libro). En forma individual o de a pares al final del cuatrimestre.

Dos clases por semana de tres horas cada una.
Determinación del horario (planilla Exel)

Outline of the Course

- Part I: Time Scales in Atomic Processes
  - ❖ Electronic orbits: Bohr's radius, period and velocity
  - ❖ Energy transitions and temporal scales
  - ❖ Characteristic times of physical systems
- Part II: Brief Introduction to Lasers:
  - ❖ Historical origin
  - ❖ Detailed balance
  - ❖ Population inversion and stimulated emission. Propagation
  - ❖ Evolution: Intensity and pulse duration
- Part III: Review of Electromagnetism
  - ❖ Maxwell's Equations
  - ❖ Lagrange's and Hamilton's Formalisms
  - ❖ Gauge Invariance
  - ❖ Classical Electron in Sinusoidal Electric Field
  - ❖ Quantum Electron in Electromagnetic Field
  - ❖ Classical Electromagnetic Radiation Field: Dipole approximation

Outline of the Course (cont.)

- Part IV: System of Units: Hartree Atomic Units
  - ❖ Relation between Hartree atomic units and SI and MKS
  - ❖ Mass, charge, and length atomic units
  - ❖ Planck constant and fine structure constant
  - ❖ Derived units: Time, frequency, electric potential, intensity and energy
- Part V: Above-Threshold Ionization
  - ❖ Ionization Conditions
  - ❖ Over the Barrier Ionization
  - ❖ Tunneling Ionization
  - ❖ Multiphoton Ionization
  - ❖ Simple Man's Model
  - ❖ Keldysh-Faisal-Reiss Theory
  - ❖ Analytical Solution of the SFA
  - ❖ Quasi-Classical Methods
  - ❖ Inter- and Intracycle interferences

Outline of the course

- Unit VI: Numerical Methods and Results
  - ❖ Numerical Solution of the TDSE
  - ❖ Pseudospectral method
  - ❖ Time evolution
  - ❖ Quantum Zeno effect: Paradox
- Unit VII: Effects of the Coulomb potential
  - ❖ Weak effects on the photoelectron spectrum
  - ❖ Strong effects on the photoelectron spectrum: rescattering
  - ❖ Quantum interference of photoelectrons
  - ❖ Quantum holography, rainbow and glory effects.
- Unit VIII: High Harmonic Generation
  - ❖ Three-step model and electronic recapture
  - ❖ High-order harmonic spectrum
  - ❖ Lewenstein Model
  - ❖ Ultrashort laser pulses and measurement of duration

Outline of the course (cont.)

- Unit IX: Laser Assisted Photoionization Emission (LAPE)
  - ❖ Soft photon approximation
  - ❖ Strong-field approximation
  - ❖ Streaking and sideband regimes: Wave-particle duality
  - ❖ Intracycle modulation of sidebands
  - ❖ Solution of the TDSE
- Unit X: Attosecond Chronoscopy: Streaking
  - ❖ Time operator in Quantum Mechanics
  - ❖ EWS time
  - ❖ Partial wave expansion: phase shifts
  - ❖ Time delays in short-range potentials
  - ❖ Time delays in long-range potentials
- Unit XI: Attosecond Chronoscopy: RABBIT
  - ❖ Reconstruction of Attosecond Beating by Interference of two-photon Transitions
  - ❖ Perturbative theory
  - ❖ Non-perturbative theory
  - ❖ Alternative methods: Attoclock

Outline of the course (cont.)

- Unit XII: Photoionization from surfaces
  - ❖ Photoionization from insulators and metals
  - ❖ Coulomb Surface Volkov Approximation
  - ❖ Band-structure-based model
  - ❖ Impulsive jellium-Volkov approximation
  - ❖ Induced potential produced by ultrashort pulses
  - ❖ Band-structure effects in photoelectron emission spectra